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Research Paper

Yield and economics of turmeric (*Curcuma longa* L.) influenced by mulching, spacing and intercropping with green gram (*Vigna radiata*)

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ABSTRACT : An experiment was conducted during *Kharif* season of 2011-12 to study from results concluded that maximum fresh rhizome yield of 210.0 q/ha obtained where turmeric sown as sole (T_2) and it was at par with T_{11} where green gram was intercropped. The maximum net return (Rs. 1,46,942) per hectare was obtained in T_{11} (30 cm inter row spacing) and it was followed by T_{10} (Rs. 1,16,080) when turmeric and green gram (37.5 cm inter row spacing in turmeric) intercropping with mulching. Mulching produced higher net return Rs. 1, 25,125 in turmeric sole with mulching as compared with Rs. 1,08,720 in turmeric sole without mulching. Highest B:C ratio 3.91 obtained in (T_2) turmeric sole with mulching than (T_1) turmeric sole without mulching. B:C ratio 3.44 obtained in T_{11} (where green gram was sown in between turmeric rows) and it was closely followed the 3.91 and 3.58 with and without mulching. Mulching increase the B:C ratio as compared to unmulched treatment. Higher turmeric equivalent yield (253.3 q ha^{-1}) obtained in T_{11} (where intercropping of green gram in between turmeric rows at 30 cm inter row spacing). Mulch application increases the land equivalent ratio as compared to without mulching. Higher LER (2.0) was obtained in T_{11} (where 30 cm inter row spacing in turmeric) and it was followed by T_9, T_7, T_8, T_{10}, T_5, T_6, T_3, T_4, T_2 treatments.

KEY WORDS : Turmeric, Mulching, Economics, B:C ratio, Returns

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INTRODUCTION :

Turmeric (*Curcuma longa* L.) is an herbaceous plant belonging to family *Zingiberaceae* and order–*Zingiberalis*. It is an important spice as well as medicinal plant and normally famous as haldi in Punjab (India). The thick underground stem is major produce of the turmeric crop. The yellow colour of the rhizome is attributed to a mixture of curcuminoides, the major being crystalline substance called curcumin. The rhizome contains 1.8-5.4 per cent of curcumin content and 2.5-7.5 per cent of essential oil (Turmerol). Turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (13.1%) (Kapoor,1990). Turmeric is grown for its rhizomes, which have many uses. It is used in the preparation of cosmetic goods, medicines and food industries, etc. It is also used as a principle ingredient in Indian culinary as curry powder. Turmeric is extensively

used as stimulant, blood purifier, remedy against skin diseases, itches, pain etc. It possesses anti cancerous properties (Kuttan *et al.*,1985) and considered cure for AIDS (Cohly *et al.*, 2003). In Unani turmeric is considered to be safest herb of choice for all blood disorders since it purifies, stimulates and builds blood (Tiwari and Agrawal, 2012). A pinch of powder boiled with milk is a traditional home remedy for cold and throat. Turmeric powder is a biologically active component with functional properties like antifungal, antioxidant, anti-inflammatory, anti-diabetic, anti-cancer, anti-bacterial, etc., (Singh and Jain, 2012).The increasing demand for natural products as food additives makes turmeric as ideal produce as food colourant.

Turmeric originated in tropical South-East Asia. It is extensively cultivated in India, Sri Lanka, Bangladesh, China, Thailand, Taiwan, Peru, Malaysia, Indonesia and Pakistan. It is extensively cultivated all over the India. Turmeric occupies about six per cent of the total area under spices and condiments in India (Moghe *et al.*, 2012). India are the largest producer, consumer and exporter of turmeric in the world. India accounts for 80 per cent of worlds output of turmeric (Anonymous, 2012). In India turmeric is mainly cultivated in Andhra Pradesh, Tamil Nadu, Orissa, Kerala, West-Bengal, Maharashtra and North-Eastern States. In India area under turmeric crop was 183 thousand hectares with production of 792 thousand tonnes (Anonymous, 2012).

Punjab being a small state in India played vital role in highest food grain production. Punjab state farmer's mostly adopting the rice-wheat crop rotation system. Farmers gain more profit from this system but they degraded the most of natural resources like underground water, soil fertility, soil fauna and flora etc. They also disturbed the agro ecosystem by incomplete biogeochemical cycles, resistance development in insect pests and diseases, reduction in soil organic matter etc. Turmeric crop has a good potential to offer an alternative to existing cereal based mono cropping system of Punjab. Presently, it is not cultivated on large scale, except by few progressive farmers. The Punjab state meets its demand from southern states. Cultivation of turmeric in the state will be helpful not only to meet its demand but also to help the country to boost its export. Turmeric is slow growing crop at its early growth phase, so it does not cover the soil very fast and the solar energy remains unutilized. It offers good scope of growing intercrop which helps in utilizing the solar radiation during period of slow growth rate in the initial growth stage of turmeric and increase remuneration of the farmers by harvesting the maximum benefits of natural resources. Green gram may be a good intercrop mature in 60 days and increase the per unit area production, which in addition to monetary benefits. It improves the soil fertility by fixing atmospheric nitrogen through N-fixing bacteria, adds organic matter to soil and also modify the microclimate of the main crop. Yamgar *et al.* (2006) and Mahfuza *et al.* (2012) observed higher yield under intercropping. Intercropping give more benefits under proper spacing, change the spacing of main crop and intercropping with other crops gave additional benefits than the sole crop. Turmeric faces major problems like poor germination; poor initial growth and large demand of irrigation water and weed infestation. To solve these problems and to reduce frequency of irrigation or to increase interval of irrigation, mulching can play an important role. Sanyal and Dhar (2008) observed the significant effect of mulching on growth and yield of turmeric.

In Punjab, Turmeric crop is sown in the end of April and beginning of May. The total area under turmeric in Punjab was around three thousand hectares with total production of about 71 thousand tones during 2011-2012 (Singh and Jain, 2012). The major turmeric growing districts in Punjab are Jalandhar, Hoshiarpur, Fatehgarh Sahib, Shaheed Bhagat Singh Nagar, Amritsar, Ludhiana, Faridkot, Gurdaspur and Ropar. The present study has, therefore, been an effort in this direction to analyze the cost and return structure of turmeric cultivation in Punjab.

MATERIALS AND METHODS :

The field experiment entitled, yield and economics of turmeric (*Curcuma longa* L.) influenced by mulching, dpacing and intercropping with green gram (*Vigna radiata* L.) was conducted at the students' Research Farm, Khalsa College, Amritsar during *Kharif* season of 2011-12 which is situated at 31° 38' N latitude with 70° 52' E longitude at an altitude of 236 m above the mean sea level. Amritsar tract is characterized by semi humid climate, where both winters and summers are extreme. The mean minimum and maximum temperature shows considerable fluctuation during summer and winter. The average maximum temperature of about 45-48^0 C is not uncommon during summer and frequent frosty spells are experienced in the months of December and January. The monsoon generally starts in the first week of July.

The average annual rainfall fluctuates around 75 mm, the major part of which is received during the months of July to September with a few showers of cyclonic rains is received during winter months.

Table A : Soil physico-chemical properties of the experimental field

Soil property	Soil depth (0-15cm)
Sand (%)	75.1
Silt	12.5
Clay (%)	12.4
Texture class	Sandy loam
Electrical conductivity at 25^0C (in mhos cm^{-2})	0.2
pH	7.4
Organic carbon (%)	0.41
Available N (kg ha^{-1})	179
Available P (kg ha^{-1})	15
Available K (kg ha^{1})	358

To assess the basic physico-chemical properties of soil, two representative soil samples were taken randomly from 0-15 cm depth before the sowing of crop. The samples collected from field were first air dried in the shade and then sieved through 2.0 mm sieve for chemical analysis and presented in Table A. The soil of experimental field was categorized as loamy-sand. The experimental field tested low in organic carbon and available nitrogen. However, available phosphorus and potassium status were medium. The soil pH and electrical conductivity values were within the normal range. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and eleven treatments in Table B.

Table B : Treatments

Sole crop of turmeric at recommended spacing (30×20 cm).	T_1
Treatment one + mulching @ 6 tonne per hectare.	T_2
One row of turmeric + one row of green gram at their standard spacing (Inter row spacing between turmeric was 60 cm).	T_3
Treatment three + mulching.	T_4
One row of turmeric + one row of green gram at 75 per cent of standard spacing of green gram (inter row spacing between turmeric was 52.5 cm).	T_5
Treatment five + mulching.	T_6
One row of turmeric + one row of green gram at 50 per cent of standard spacing of green gram (inter row spacing between turmeric was 45 cm).	T_7
Treatment seven + mulching.	T_8
One row of turmeric + one row of green gram at 25 per cent of standard spacing of green gram (inter row spacing between turmeric was 37.5 cm).	T_9
Treatment nine + mulching.	T_{1O}
One row of green gram sown in between turmeric crop where no extra spacing was given to green gram (inter row spacing between turmeric was 30 cm).	

RESULTS AND DATA ANALYSIS :

The results of the present investigation entitled, yield and economics of turmeric (*Curcuma longa* L.) influenced by mulching, spacing and intercropping with green gram (*Vigna radiata*) are presented in this chapter. The observations recorded with respect to various growth, yield and yield attributes of turmeric and green gram crops are presented and discussed in this chapter.

Fresh rhizome yield of turmeric :

Rhizome yield of turmeric per unit area is the main concern to the economy of the growers. The data revealed that in Table 1 produced fresh rhizome yield of turmeric significantly higher in T_2 followed by T_1, T_3, T_4,

Table 1 : Effect of different treatments on fresh rhizome yield of turmeric (q/ha)

Treatments	Fresh rhizome yield of turmeric (q/ha)
T_1 (T_{Sole})	188.4
T_2 (T_{Sole}+M)	210.0
T_3 (1RT+1RGG) (60cm inter row spacing in turmeric)	117.5
T_4 (T_3+M)	125.3
T_5 (1RT+1RGG) (52.5cm inter row spacing in turmeric)	132.1
T_6 (T_5+M)	135.5
T_7 (1RT+1RGG) (45cm inter row spacing in turmeric))	150.6
T_8 (T_7+M)	157.7
T_9 (1RT+1RGG) (37.5cm inter row spacing in turmeric)	170.5
T_{10} (T_9+M)	176.4
T_{11} (1RT+1RGG) (30 cm inter row spacing in turmeric)	205.9
C.D. (P=0.05)	19.87

T_5, T_6, T_7, T_8, T_9, T_{10} and at par with T_{11}. Sole turmeric with mulching treatment (T_2) in Table 1 produced maximum yield (210.0 q/ha) as compared to other intercropping treatment combinations with or without mulch application. This was due to the higher plant population under sole turmeric with mulching as compared to intercropping or without mulching treatments. Turmeric intercropped with green gram (30 cm inter row spacing in turmeric) produced (205.9 q/ha) fresh rhizome yield closely followed by sole turmeric with mulching (210.0 q/ha). Silva *et al*. (2004) and Kandiannan and Chandaragir (2006) reported that the yield of turmeric was highest at closer spacing. Turmeric and green gram (60 cm inter row spacing in turmeric) intercropping system obtained least yield (117.5 q/ha) of fresh rhizome as compared with other intercropping treatments. It may be due to less number of plants per unit area. Green gram intercrop covers half an area of the total area, resulting decrease in the plant population of turmeric as compared with sole turmeric. Manhas *et al.* (2011) also recorded the higher fresh rhizome yield with mulching.

Economics :

Data presented in Table 2 showed that maximum net returns of Rs. 1,46,942/- per hectare was obtained when green gram sown in between turmeric rows (T_{11}) at 30 cm inter row spacing. The highest net returns might be due to intercrop of green gram obtained maximum

Table 2: Effect of different treatments on net return over variable cost (Rs./ha) and B:C ratio of turmeric and green gram intercropping system

Treatments	Gross return from turmeric (Rs./ha)	Gross return from inter crop (green gram) (Rs./ha)	Total return (Rs./ha)	Total cost (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1 (T_{Sole})	1,50,720	------	1,50,720	42,000	1,08,720	3.58
T_2 (T_{Sole}+M)	1,68,000	-------	1,68,000	42,875	1,25,125	3.91
T_3 (1RT+1RGG) (60cm inter row spacing in turmeric)	94,000	27,200	1,21,200	47,456	73,744	2.55
T_4 (T_3+M)	1,00,240	28,480	1,28,720	47,856	80,864	2.68
T_5 (1RT+1RGG) (52.5cm inter row spacing in turmeric)	1,05,680	29,400	1,35,080	51,148	83,932	2.64
T_6 (T_5+M)	1,08,400	30,880	1,39,280	51,456	87,824	2.70
T_7 (1RT+1RGG) (45cm inter row spacing in turmeric))	1,20,480	31,800	1,52,280	57,425	94,855	2.65
T_8 (T_7+M)	1,26,160	32,880	1,59,040	58,542	1,00,498	2.71
T_9 (1RT+1RGG) (37.5cm inter row spacing in turmeric)	1,36,400	33,080	1,69,480	59,415	1,10,065	2.85
T_{10} (T_9+M)	1,41,120	34,480	1,75,600	59,518	1,16,082	2.95
T_{11} (1RT+1RGG) (30 cm inter row spacing in turmeric)	1,64,720	42,200	2,06,920	59,978	1,46,942	3.44

MSP of turmeric rhizome was Rs. 800/- quintal in the year 2011-12

Table 3 : Effect of different treatments on turmeric equivalent yield (TEY) q ha^{-1} and land equivalent ratio (LER) of turmeric

Treatments	Turmeric equivalent yield (TEY) q/ha	Land equivalent ratio (LER)
T_1 (T_{Sole})	188.4	1.0
T_2 (T_{Sole}+M)	210.0	1.11
T_3 (1RT+1RGG) (60cm inter row spacing in turmeric)	148.1	1.21
T_4 (T_3+M)	157.3	1.20
T_5 (1RT+1RGG) (52.5cm inter row spacing in turmeric)	165.1	1.33
T_6 (T_5+M)	170.2	1.31
T_7 (1RT+1RGG) (45cm inter row spacing in turmeric))	186.3	1.48
T_8 (T_7+M)	194.6	1.46
T_9 (1RT+1RGG) (37.5cm inter row spacing in turmeric)	207.7	1.61
T_{10} (T_9+M)	215.1	1.58
T_{11} (1RT+1RGG) (30 cm inter row spacing in turmeric)	253.3	2.0

gross returns because more number of plants of green gram. Least net returns of Rs. 73,744/- obtained in T_3 when turmeric was sown with 60 cm inter row spacing without mulching. Net returns of turmeric was in sole (Rs. 1,25,125/- per hectare) with mulching as compared with net returns of Rs. 1,08,720 per hectare in turmeric sole of without mulching. The higher net returns under mulching as compared to pure crop have also been reported by Singh (1983). B:C ratio of (3.91) higher in turmeric sole with mulching as compared to turmeric sole (3.58) without mulch. Mulching increases the B:C ratio as compared with no mulch application in all treatments. B:C ratio 3.44 obtained in T_{11} at 30 cm inter row spacing in turmeric which was closely followed by the turmeric sole (3.91) with mulching. Benefit cost ratio was in descending order in treatments T_2, T_1, T_{11}, T_{10}, T_9, T_8, T_6, T_4, T_7, T_5 and T_3 and it was 3.91, 3.58, 3.44, 2.95, 2.85, 2.71, 2.68, 2.65, 2.64 and 2.55. Green gram sole obtained net returns of Rs. 38,280 having B:C ratio 5.90.

Turmeric equivalent yield :

The data presented in Table 3 revealed that maximum turmeric equivalent yield (253.3 q/ha) was obtained when green gram (30 cm inter row spacing in turmeric) intercropped in between turmeric rows as compared to turmeric sole with mulching (210.0 q/ha) and other intercropped treatments. Turmeric equivalent yield was in descending order in treatments T_{11}, T_{10}, T_2, T_9, T_8, T_1, T_7, T_6, T_5, T_4 and T_3 where it was 253.3, 215.1, 210.0, 207.7, 194.6, 188.4, 186.3, 170.2, 165.1, 157.3 and 148.1 q/ha. Turmeric equivalent yield (TEY) is calculated as under:

$$\textbf{Turmeric equivalent yield (TEY)} = \sum_{i=0}^{1} (\mathbf{Yi.ei})$$

where, Yi is yield of ith component and ei is the equivalent factor of ith component or price of the ith crop.

Land equivalent ratio :

Land equivalent ratio is the relative land area under sole crop is required to produce the yield achieved in intercropping. The data revealed that maximum land equivalent ratio 2.00 (Table 3) achieved in treatment T_{11} where spacing between turmeric was 30 cm. It was followed by T_9 (1.61), T_{10} (1.58), T_7 (1.48), T_8 (1.46), T_5 (1.33), T_6 (1.31), T_3 (1.21), T_4 (1.20), T_2 (1.11), T_1 (1.00) and T_{12} (1.00), respectively. LER is higher in T_{10} may be due to beneficial effect of intercrop and mulching, where as benefit decrease with decrease in plant population at T_9, T_7, T_5 and T_3 where spacing was more, mulch was not applied. Treatments where mulching were applied gave more LER than without mulch irrespective of intercropping. The land equivalent ratio (LER) is calculated as under :

$$\textbf{Land equivalent ratio (LER)} = \sum_{i=1}^{m} \frac{\mathbf{Yi}}{\mathbf{Yij}}$$

where, Y_i is the yield of ith component from a unit area grown as intercrop and Y_{ij} is the yield of i^{th} component grown as sole crop over the same area. In brief, LER is summation of ratios of yields of intercrop to the yield of sole crop.

Conclusion :

From the study yield and economics of turmeric (*Curcuma longa* L.) influenced by mulching, spacing and intercropping with green gram (*Vigna radiata*) concluded that to get more returns, land equivalent ratio and turmeric equivalent yield. Mulching increase the fresh, dry and processed rhizomes yield as compared to without mulch application. Maximum fresh rhizome yield of 210.0 q/ha obtained where turmeric sown as sole (T_2) and it was at par with T_{11} where green gram was intercropped. Turmeric intercropping with green gram at 30 cm inter row spacing is a good option. Application of mulches produced significantly higher yield and net returns as compared to without mulching. Mulching increase the B:C ratio, equivalent yield and land equivalent ratio as compared to without mulched treatment.

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